NACA RM No. L8H31a

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RESEARCH MEMORANDUM

CLASSIFICATION CHANGED TO
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DATE 1-8-54 T.C.F.

EFFECT OF STRUT-MOUNTED WING TANKS ON THE DRAG OF NACA RM-2 TEST VEHICLES IN FLIGHT AT TRANSONIC SPEEDS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

November 18, 1948

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SUMMARY

Results of a free-flight investigation near zero lift of an NACA RM-2 drag research model equipped with strut-mounted wing tanks of fineness ratio 7.44 are presented for a Mach number range from about 0.7 to 1.1. The addition of the struts and tanks to the winged model caused the drag rise to occur at a lower Mach number and produced a drag-coefficient increment based on the frontal area of two tanks of 0.075 at a Mach number of 0.72 which increased to 0.82 (the maximum increment obtained) at a Mach number of 1.06. The data indicate that the struts and tanks may produce significant trim changes in the range of Mach numbers investigated.

INTRODUCTION

The difficulties associated with the prediction of the drag characteristics of general wing-nacelle combinations at transonic speeds have created a need for experimental data in this region. The Langley Pilotless Aircraft Research Division has initiated a program, utilizing NACA RM-2 drag research models, from which it is hoped to determine the drag increments resulting from the variation of the position of bodies simulating external fuel tanks or nacelles on a swept wing. The present paper contains information obtained from tests of NACA RM-2 drag research models having untapered, 34° sweptback wings of 2.7 aspect ratio with and without strut-mounted bodies of revolution. The strut-body combination is typical of the wing fuel-tank installation contemplated for use on a projected fighter-type airplane configuration. However, for this investigation, the tanks were mounted on opposite surfaces of each wing panel. (See fig. 1.) The data are presented as plots of drag coefficient and wing-tip helix angle against Mach number. From these data, the drag as well as the approximate magnitude of the trim change due to the addition of the tanks and struts can be determined.

SYMBOLS

$pb/2V$	wing-tip helix angle, radians
p	rolling velocity, radians per second
b	diameter of circle swept by wing tips, feet
V	velocity along flight path, feet per second
C_{D_T}	total drag coefficient based on exposed wing area
C_{D_t}	drag coefficient of struts and tanks based on frontal area of two tanks
M	Mach number
A	aspect ratio (b^2/S)
S	exposed wing area
R	Reynolds number

MODELS

The general arrangement of the NACA RM-2 test vehicles used in the present investigation is shown in figures 1 and 2. The basic model construction, described in reference 1, has been altered only by the substitution of a spinsonde nose (reference 2) for the standard wooden one. The tank and strut, of wooden fabrication, were attached to the wing in the relative position indicated in figure 3. The tank had a fineness ratio of 7.44 and the strut had an average thickness to chord ratio of 0.065. For convenience, the location of the tank can be expressed in percentage of the wing chord. These percentages are 55.5 for the perpendicular distance from the body center line outboard to the tank center line, 32.6 for the distance from the wing chord line to the tank center line, and 74.0 for the distance from the nose of the tank to the leading edge of the wing. Four models were used in the investigation, two models without tanks or struts (6c and 6d) and two models with one tank mounted on opposite surfaces of each wing panel (1c and 1d). The tanks were mounted in this manner to avoid the trim changes that would obscure the true nature of the drag by introducing unknown variations in angle of attack. By measuring the resulting rate of roll, utilizing the technique described in reference 2, an indication of the trim change caused by the tanks and supports was obtained. In order to establish

an index of the rolling asymmetry inadvertently built into the models, the rate of roll was also determined for models 6c and 6d.

The models were propelled by 3.25-inch aircraft rocket motors which were contained within the fuselage. At a preignition temperature of 69° F, the rocket motors provided approximately 2200 pounds of thrust for about 0.87 second.

TESTS

The launchings of the test vehicles were accomplished at the Pilotless Aircraft Research Station, Wallops Island, Va. The testing technique whereby drag-coefficient data are obtained has been adequately described in reference 3. The accuracy of the drag coefficients is estimated to be ±0.002 at Mach numbers above 1.0; ±0.003 at Mach numbers below 1.0. The accuracy of the Mach number determination is estimated to be within ±0.01.

The rolling velocity of each model and the resultant wing-tip helix angle $pb/2V$ were determined by the technique described in reference 2. The maximum error in the quantity $pb/2V$ is estimated to be ±0.0025.

The large scale of the tests is indicated by the range of Reynolds number shown in figure 4. The Reynolds number is based on the model wing chord (9.647 in.) parallel to the body center line.

RESULTS AND DISCUSSION

The total drag coefficient C_{D_T} is presented in figure 5 plotted against Mach number M for all models tested. Previous data have been obtained for two models similar to 6c and 6d and these data have been presented in reference 1. The present results obtained from the tests of models 6c and 6d indicate slightly higher values of C_{D_T} over the comparable Mach number range. This difference may be attributed to the fact that the Plexiglas spinsonde noses used on the present models (to obtain rolling velocity) do not provide as clean an installation as the standard wooden noses otherwise employed. A faired curve has been drawn for each set of data representing similar configurations. The wingless curve has been slightly modified from the one of reference 3 by the addition of recent data.

The data show that the presence of the tanks caused the drag rise to occur at a noticeably lower Mach number. It is believed that this effect may be indicative of undesirable peak-pressure interference between the tank, strut, wing, and body that may be improved by suitable

tank geometry or location. The drag-coefficient increment due to the tanks and struts which includes interference effects was determined by taking the drag difference between tanks-on and tanks-off configurations and is presented in figure 6 based on the frontal area of two tanks. At $M = 0.72$, this increment is 0.075 increasing to 0.82, the maximum value obtained at $M = 1.06$. In order to determine further the over-all effect of the general arrangement, the drag results obtained for a body of fineness ratio 6.0 having essentially the same profile as the tank used in the present tests have been replotted from reference 4. Examination of the curves indicates a very large drag-coefficient increment, that may be attributed to the presence of the strut and its associated interference effects.

An estimate of the trim change due to the tanks was obtained by utilizing the values of $pb/2V$ presented in figure 7. Examination of figure 7 reveals the variation of $pb/2V$ with Mach number for the models with and without strut-mounted tanks. The models without tanks showed very small rates of roll, producing values of $pb/2V$ close to zero which would indicate small asymmetries built into the models. The curves obtained for models 1c and 1d are in close agreement and show variations typical of the type produced by partial-chord plain ailerons. The presence of each strut and tank apparently produces high velocity flows over the near wing surface which induces roll, or a lift increment toward the tank. On the basis of tests reported in reference 5, the value of $pb/2V$ developed at $M = 1.0$ is equivalent to the rolling velocity produced by a full-span 0.2-chord plain aileron deflected about 1°. From the values of $pb/2V$ obtained for the tanks-on configuration, the angle of attack of the wing tip and the tank center-line wing station were calculated as 0.9° and 0.37°, respectively, at $M = 0.8$ and 0.79° and 0.33°, respectively, at $M = 1.0$ with a reduction to zero in the region around 0.90. The lift-coefficient increment applied at the tank center line to produce the $pb/2V$ values shown in figure 7 was estimated from reference 6 and unpublished data to be about 0.03 at $M = 0.8$. Thus, it is apparent that an airplane incorporating similarly located but conventionally arranged strut-mounted tanks of the type tested may experience significant trim changes at Mach numbers in the range investigated.

CONCLUDING REMARKS

A rocket-powered flight investigation of NACA RM-2 drag research models with and without strut-mounted wing tanks has been conducted near zero lift for comparable Mach numbers ranging from about 0.7 to 1.1. The tank was a body of revolution of fineness ratio 7.44. The addition of the struts and tanks to the model increased the drag coefficient based on the frontal area of two tanks by 0.075 at a Mach number of 0.72 and by 0.82 (the maximum increment obtained) at a Mach number of 1.06. Attachment of

the tanks also caused the drag rise to occur at a lower Mach number. The data indicated that the strut-mounted tanks, when attached in a conventional manner, may produce significant trim changes in the Mach number range investigated.

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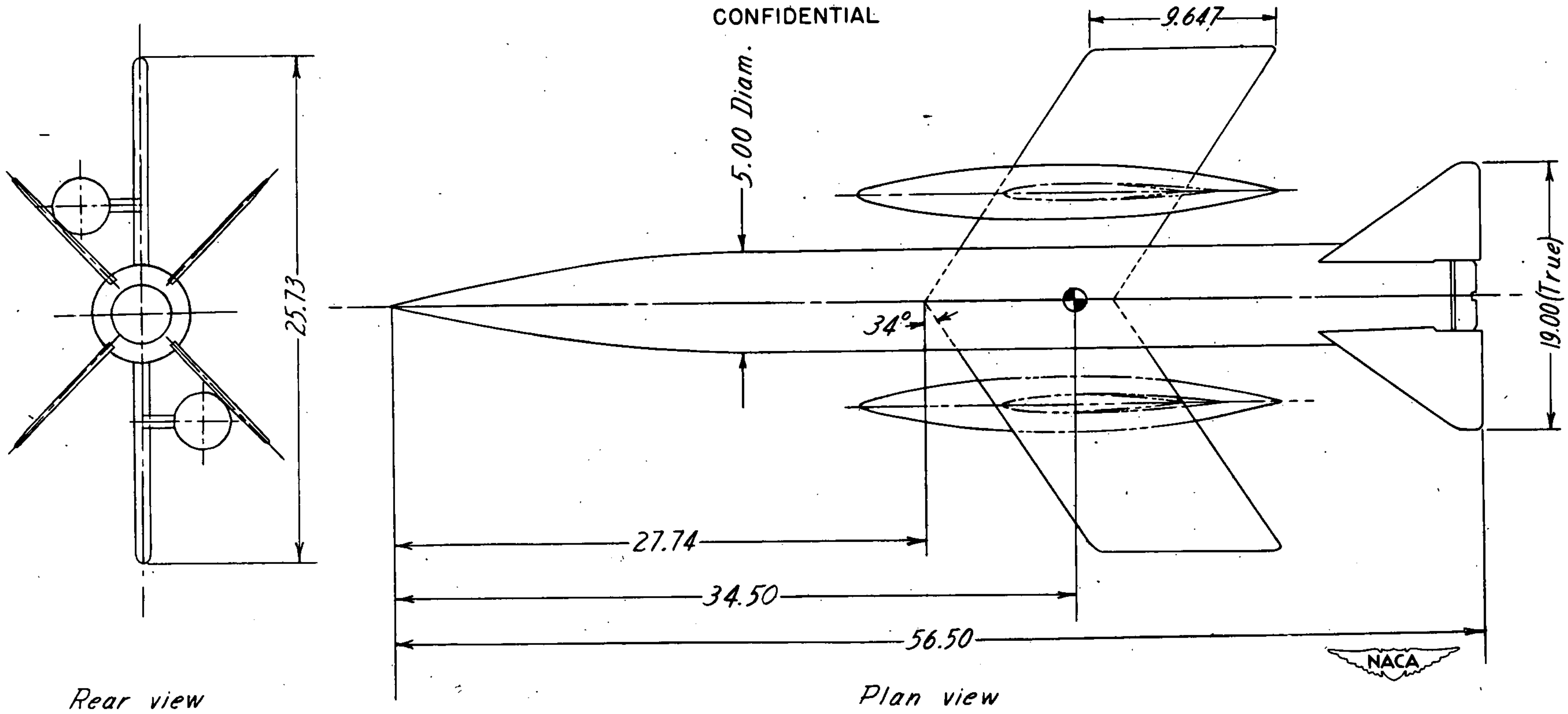

Figure 1.- General arrangement of RM-2 drag research vehicle with strut-mounted wing tanks. (All dimensions are inches.)

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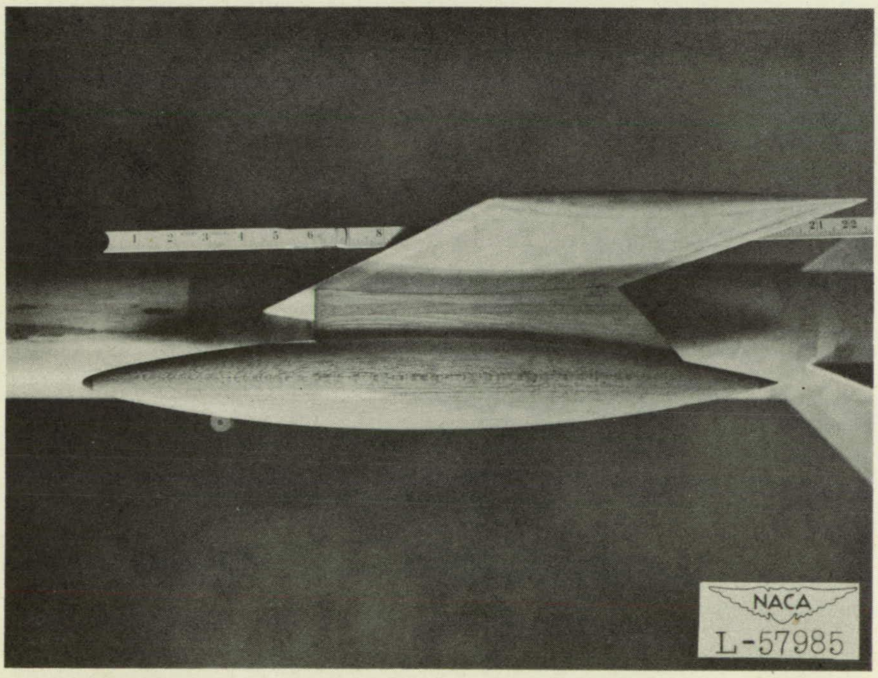

Figure 2.- Typical strut-mounted wing-tank installation on NACA RM-2 model.

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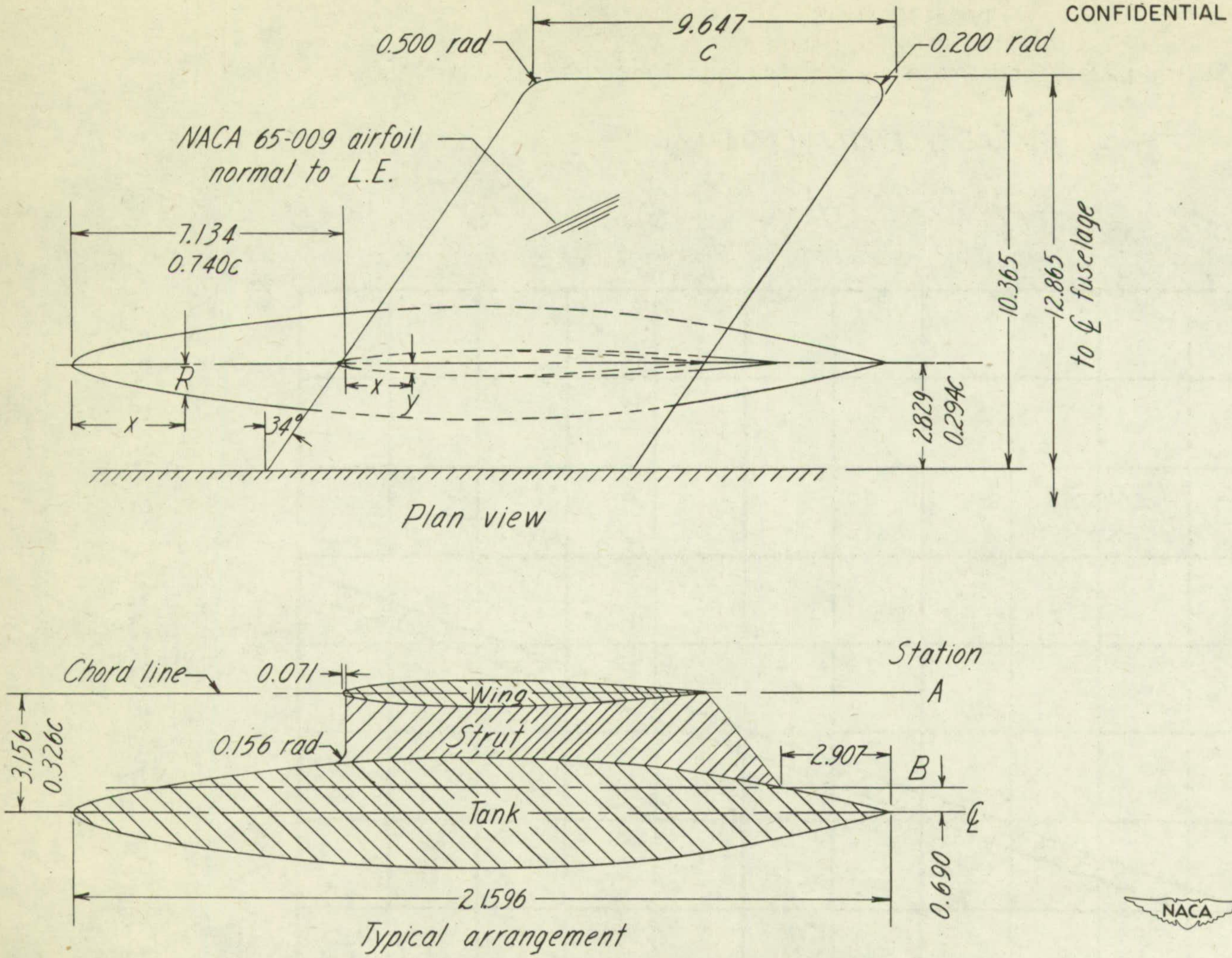

Strut coordinates			
Station A		Station B	
x	y	x	y
.048	.051	.048	.051
.072	.066	.072	.066
.119	.083	.119	.083
.239	.115	.239	.115
.479	.161	.479	.161
.718	.198	.718	.198
.958	.222	.958	.222
1.915	.296	1.915	.296
2.873	.327	2.873	.327
3.830	.340	3.830	.340
4.788	.327	5.118	.327
5.746	.301	6.410	.301
6.703	.251	7.704	.251
7.661	.183	8.985	.183
8.618	.099	10.270	.099
9.576	.000	11.556	.000
L.E. radius = 0.049			

Tank coordinates			
x	R	x	R
.083	.1128	10.383	1.454
.249	.2014	10.798	1.453
.415	.2664	12.465	1.415
.831	.395	14.120	1.315
1.662	.593	15.789	1.149
2.792	.758	16.612	1.041
4.153	1.019	17.451	.916
4.986	1.126	18.273	.772
5.814	1.216	19.113	.609
6.648	1.292	19.944	.426
7.475	1.353	20.775	.223
8.306	1.399	21.191	.114
9.136	1.432	21.596	.000
L.E. radius = 0.079			
T.E. radius = 0.020			

Figure 3.- Details of wing-tank installation on NACA RM-2 model. Tank fineness ratio = 7.44. (All dimensions are inches.)

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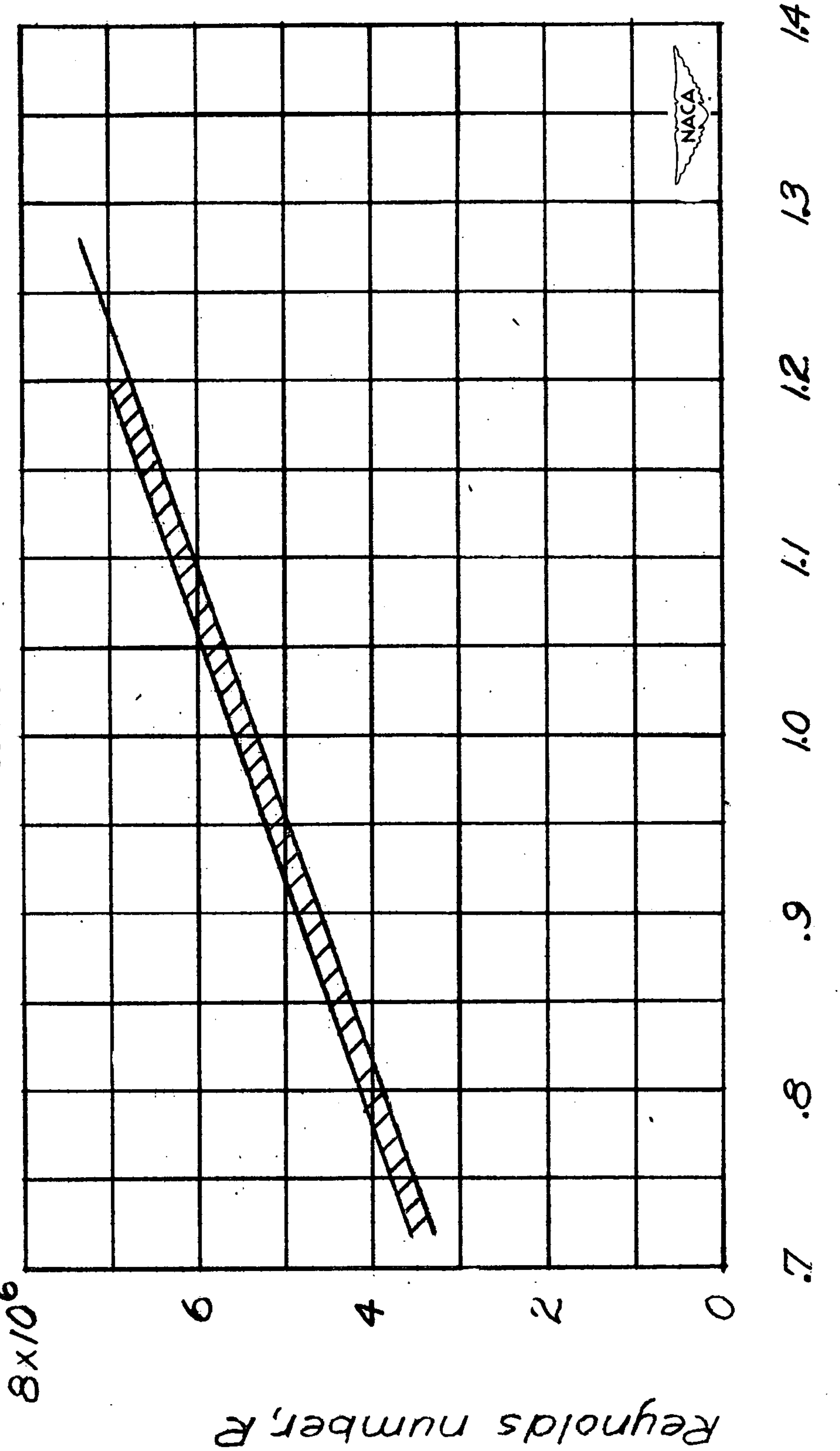

Figure 4.- Range of Reynolds numbers for conditions encountered during model tests based on wing chord of 9.647 inches.

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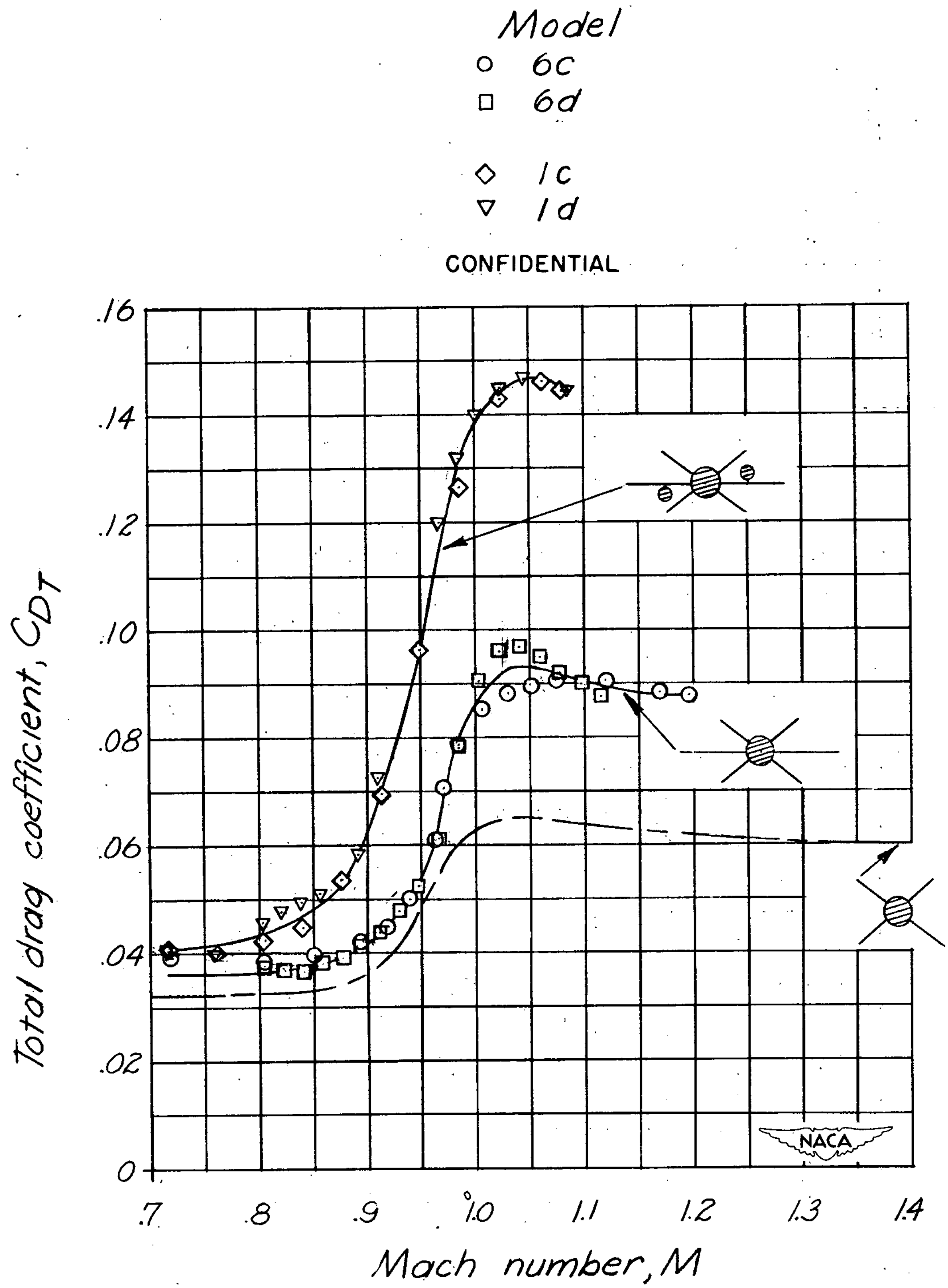

Figure 5.- Total drag-coefficient data based on exposed wing area of 200 square inches. RM-2 test vehicles with and without strut-mounted wing tanks. Aspect ratio = 2.7; sweepback angle = 34°.

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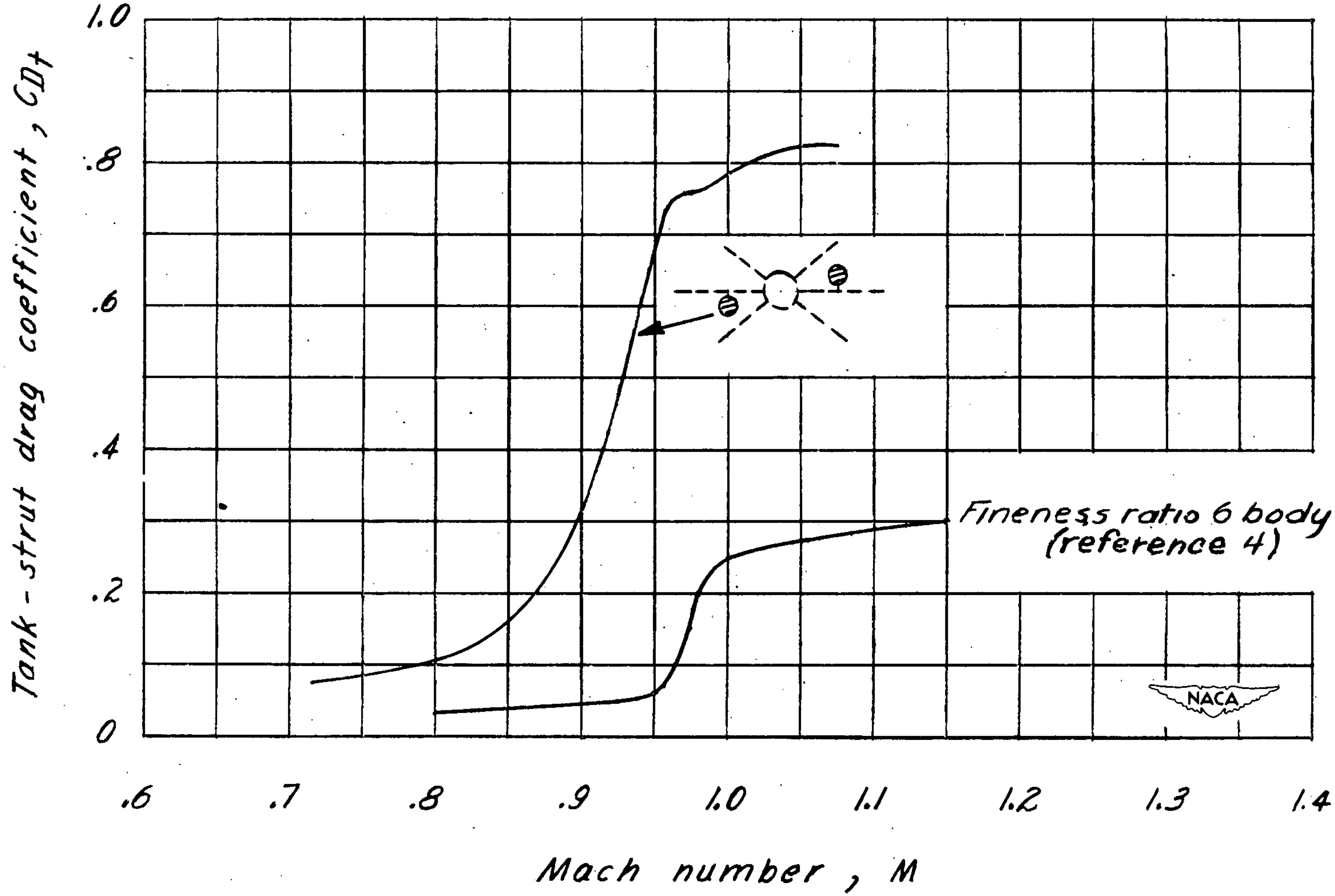

Figure 6.- Tank-strut drag coefficients based on area of two tanks equal to 13.2 sq in. Tank fineness ratio = 7.44.

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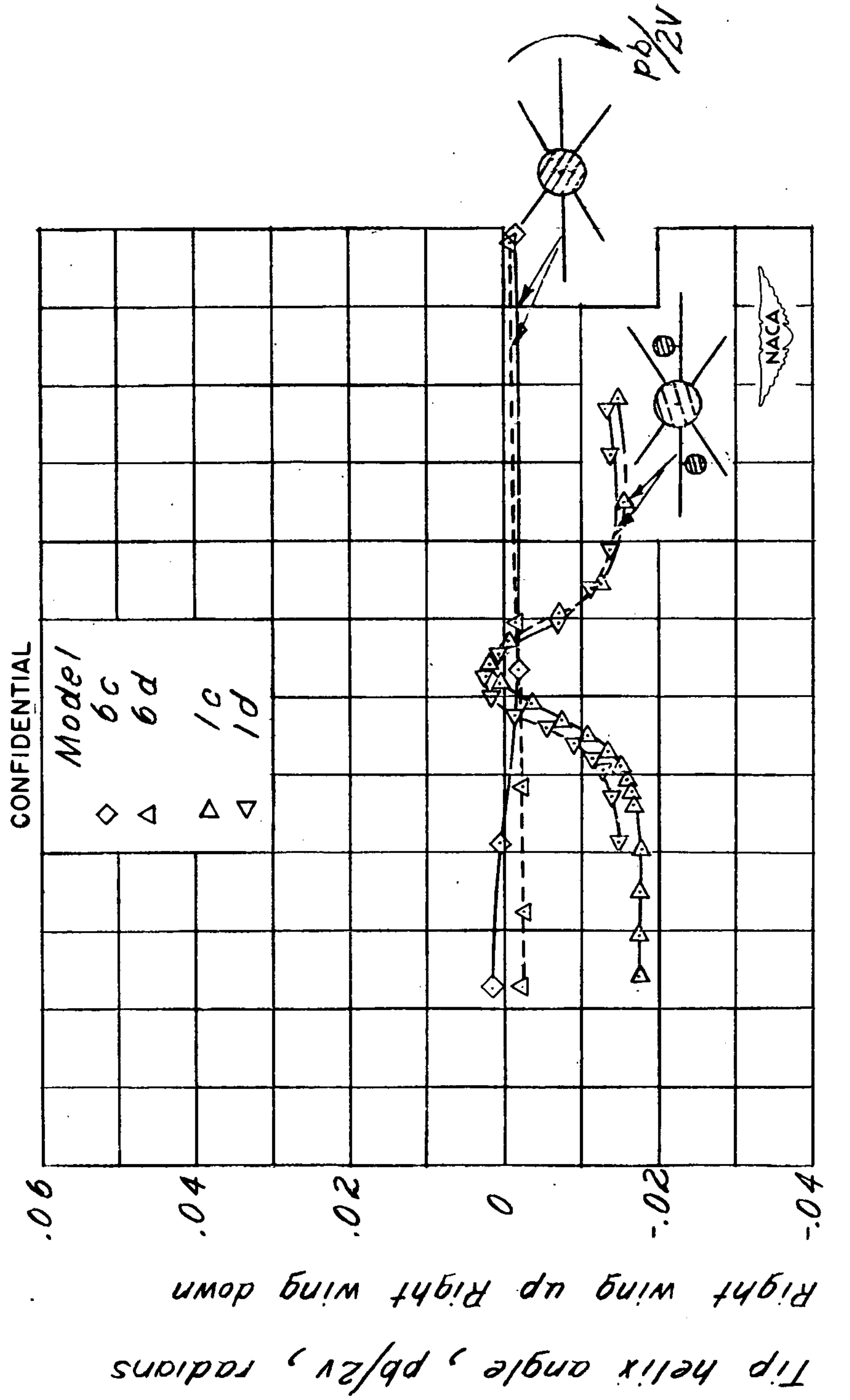

Figure 7.- Wing-tip helix angle produced by strut-mounted wing-tank combination. NACA RM-2 test vehicle.

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